Multi-level Immune Learning Detection (MILD)

MILD is an anomaly detection tool based on the negative selection algorithm inspired by the human immune system.

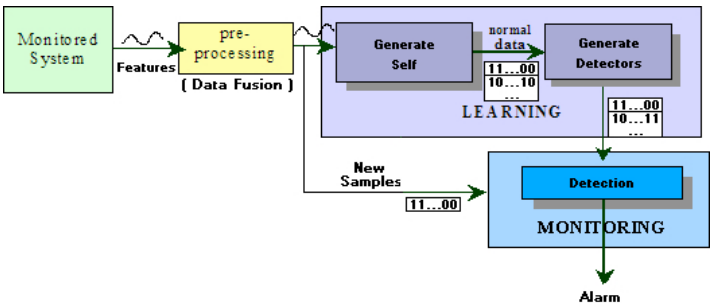
Background

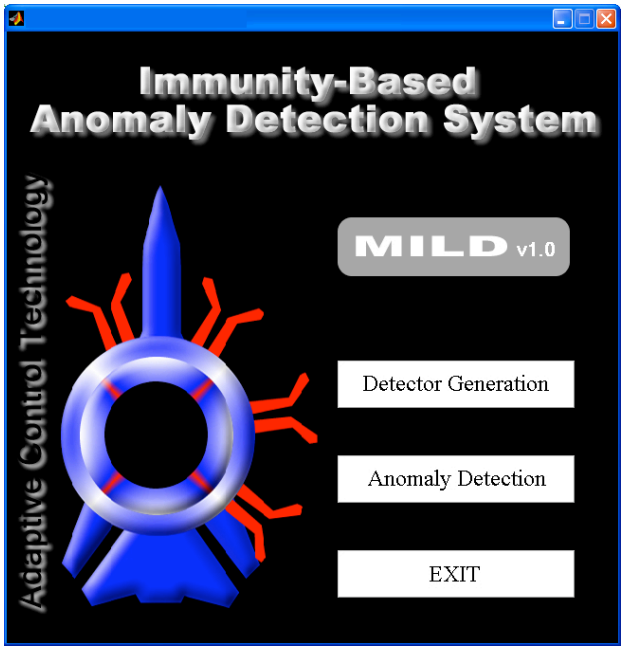
Early detection of anomalies in spacecraft subsystems is very crucial for safe operation. There are several techniques available for fault detection and isolation issues. Our work implements an immunity-based approach that can detect a broad spectrum of known and unforeseen anomalies. The approach is based on the concept of negative space, i.e., looking for behaviors outside of what is defined as normal. First version of the tool is being tested using datasets collected under normal and various simulated failure conditions using the NASA Ames man-in-the-loop high-fidelity C-17 flight simulator. The tool is developed in Matlab.

Research Overview

The MILD software tool implements an immunity-based technique for anomaly and fault detection. The technique uses a real-valued Negative Selection Algorithm (NSA) inspired by the biological immune system. The negative selection algorithm is based on the principles of self-nonself discrimination in the immune system. This negative selection algorithm can be summarized as follows:

- Define self as a collection *S* of elements in a feature space *U*, a collection that needs to be monitored.
- Generate a set *F* of *detectors*, each of which fails to match any string in *S*.
- Monitor *S* for changes by continually matching the detectors in *F* against *S*. If any detector ever matches, then a change is known to have occurred, as the detectors are designed not to match any representative samples of *S*.





The detection algorithm uses sensory data exhibiting the normal behavior patterns to generate probabilistically a set of fault detectors that can detect many anomalies (including faults and damages) in the behavior pattern of the system response.

Relevance to Exploration Systems

Space exploration with enhanced margins and redundancy imply increased cost. Efficient anomaly detection has a system-wide impact when reduced margins and decreased redundancy drive the designs.

H&RT Program Elements:
This research capability supports the following H&RT program /elements:
ASTP/Software, Intelligent Systems & Modeling

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